

Clinical Diagnosis of Dental Caries: A Perspective

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Abstract:

The aim of this paper is to provide a broad international perspective on aspects of the RTI/UNC systematic review, to introduce relevant literature not cited and to make recommendations for clinical practice education and research suggested by the evidence. Clinical caries diagnosis represents the foundation on which the answers to most of the consensus questions will be based. This paper highlights needs for: clarity about definitions and nomenclature, understanding the importance of the concepts underlying the D₁ and D₃ diagnostic thresholds used widely within the RTI/UNC Review, appreciating that the diagnostic challenge now faced by clinicians is significant and becoming more complex as the presentation and distribution of the disease changes over time and the range of preventive and operative treatment options expands. A series of recommendations informed by the evidence are made, including a rather contentious issue for many clinicians concerning the lack of evidence supporting the continued use of a sharp explorer as a diagnostic tool for primary caries diagnosis. This practice should be discontinued as it may cause some harm to the patient and yet fails to provide a significant balancing diagnostic benefit. Finally it is suggested that Dentistry should learn from the developing evidence base in Medicine on how best to disseminate the findings of reviews and promote appropriate changes in clinical practice.

Keywords: dental caries, diagnosis; evidence based dentistry; treatment strategies; dental diagnostic systems

PERSPECTIVE ON THE CONSENSUS DEVELOPMENT CONFERENCE

I would applaud the organizers for setting out such an important and timely agenda for this Conference which is, in a sense, overdue. I would also caution all participants as to the enormity of the task set out for us. Agreeing where the evidence leads us on the Diagnosis and Management of Dental Caries Throughout Life is a complex task, but one in which we should be able to make significant and valuable progress. The focus of the Conference is rightly on clinical practice and using current knowledge to aid the provision of the best possible appropriate care for individual patients. It is important at the outset to realize that much of the research work in the field of caries diagnosis has been conducted and reported in three overlapping applications of the diagnostic process: clinical practice, clinical research and clinical dental epidemiology. The differing objectives, environments and priorities of research and work in these areas often confuse attempts to synthesize the relevant literature, particularly when comparing across countries and dental cultures.

As the aim of conference is to develop scientifically based recommendations that can be applied by dentists and dental hygienists, it is important that the “everyday” fundamentals of clinical caries diagnosis are addressed clearly and objectively. Clinical caries diagnosis represents the foundation on which the answers to most of the consensus questions will be based, either through providing information on caries detection (or acting as the benchmark from which other methods must be judged), being part of risk assessments, being used in the

assessment of both primary and secondary preventive strategies, as well playing a key role in informing clinical decision making. It is vital then that the objective findings of the RTI/UNC systematic review around which the Conference is based, as well as those from a number of other reviews from a variety of countries are carefully considered by the target group of end users – even if some of the findings seem to contradict the dental “facts of life” taught to many of us in an earlier era as undergraduates in different dental schools, and even if some of the more recent findings do not fit with the “classical” findings of research carried out some years ago. Different groups of clinicians in different countries will probably find different parts of the recommendations easy or difficult to comply with. We should learn from the work done in Medicine that there is also a developing literature and evidence base on how to disseminate the findings of reviews effectively and, having achieved that, how any changes in clinical practice that might be indicated can best be brought about.¹ The potential for this conference to contribute to professional behavior change looks favorable, in those initiatives that are professionally led and are conducted to a high scientific standard with systematic and objective reviews of the international literature have been shown to work well, as long as they are then cascaded down to achieve true local ownership.¹

A key area, which will need to be addressed to build and achieve consensus, is clarity about the definitions and nomenclature used. Many apparently similar terms are often used interchangeably in the literature but are taken by different groups of researchers and clinicians to mean very different things. In the conference title (and hence the mission) there will have to be clarity with regard to defining the terms: **Diagnosis** (not just detection), clinical **Management** (encompassing preventive care of reversible lesions as well as surgical excision of tooth substance), just what constitutes **Dental Caries** (the current research view, held for many years in Europe and now increasingly in the US, is that caries is a continuum,

rather than just the macroscopic cavitation - which merely represents the late-stage of the disease process), **Throughout Life** (here we will need clarity to differentiate Early Childhood Caries from lesions in children, adolescents, adults and seniors, to plan minimally invasive care for the long term benefit of the patient, and to appreciate the possibility of changes between risk groups over time).

A (EUROPEAN) PERSPECTIVE ON THE PARTS OF THE RTI SYSTEMATIC REVIEW RELATING TO CLINICAL CARIES DIAGNOSIS

To make best use of the Review it is very important to understand the concepts of the D₁ and D₃ diagnostic thresholds used widely within the RTI/UNC Review; this is an area which causes confusion to many. Figure 1a shows an updated version of the iceberg metaphor for conceptualizing dental caries and the impact which changing diagnostic threshold has on what is considered by dentists and researchers to constitute sound and diseased tooth tissue.² The term “caries free” is frequently used when referring to data reported at the D₃ (caries into dentin only) diagnostic threshold. This conveys the mistaken impression that there is no disease present in an individual or population, even though large numbers of carious lesions recognized and scored by dentists and researchers as dental caries in the enamel are present.³ The diagnosis of so called “white spot” and “brown spot” caries has been accepted for many years in Europe and monitoring the behavior of these lesions over time using clinical caries assessments is routine following the classic work of Backer-Dirks and others.⁴ It has been shown that the progression of these enamel lesions with macroscopically intact surfaces is extremely slow and such lesions on free smooth surfaces do not always progress; they can stop - *lesion arrest*, or even reverse - *lesion regression*.^{5,6} Part of the confusion is that these enamel lesions are often referred to as D₁ lesions, as opposed to the D₁ diagnostic threshold that includes **both D₁ and D₃** lesions (Figure 1). An

example of the type of clinical visual diagnostic criteria used often in European studies, which can be reported at either or both the D₁ and D₃ diagnostic thresholds, is the recently reported Dundee Selectable Threshold System - DSTM.^{7,8} Note that traditional diagnostic aids (such as bitewing radiography and Fiber-optic transillumination – FOTI) detect more lesions still. The newer and more sensitive research methods of caries diagnosis are now able to detect even more sub-clinical initial lesions, which are in a state of dynamic progression and regression at the early stage of the disease process, before they are discernible by conventional clinical methods. This gives the potential for lesions to be detected and for the impact of preventive care to be assessed in order to ensure that cavitation is avoided.

The same iceberg can be used to link the diagnostic divisions of the continuum of dental caries with the type of clinical caries management option that offers the patient the best long-term benefit (Figure 1b). This choice of the most appropriate care option involves balancing the risk of continuing tooth destruction if preventive care fails, against restorations placed and then replaced repeatedly over time with the imperfect restorative methods currently available. The approach used in Europe for some years is summarized by the acronyms **NCA** for **No (active) Care Advised** above normal prevention, **PCA** for **Preventive Care Advised** when stable and / or non-cavitated lesions are diagnosed and **PCA + OCA** when both **Preventive** and **Operative Care** are **Advised** for progressive dentinal lesions and lesions with significant cavitation.^{9,10} There is a continuing debate in Europe as to exactly when restorative intervention is indicated with a movement to recognize the need to tailor the decision to individual patients and their needs, wants and circumstances, with a focus on cavitation (surface discontinuity) rather than dentin involvement (lesion depth) per se. It should be noted that progressive dentinal hidden dentine lesions can sometimes be found in sites that are clinically sound and that these lesions are scheduled for operative care (Figure

1b). It also must be emphasized and re-emphasized that clinical caries diagnosed at the enamel lesion threshold with intact surfaces are **NOT** scheduled for restoration, but are typically managed preventively in Europe.

There are a number of technical aspects of the Review that are worthy of comment. Firstly the reviewers are to be congratulated for their diligence, endurance and thoroughness in completing such a major task. The key finding that the quality of studies in the areas reviewed was often found to be poor may be seen as contentious by some in dentistry. It is frustrating that, when measured against contemporary methodological standards, there are so few useable studies. However, it is important for these findings to be judged in the context of similar reviews in many fields of medical care where similar findings are common. This represents a major challenge to the dental research community for the future.

Some areas of the review might have been improved if more time and resource were available. A key concern in this complex area of reviewing diagnostic literature in Evidence Based Healthcare is that the quality standards imposed on grading the papers included are pertinent to the objective(s) of the study. In this review as data from some papers were employed for a number of different analyses, not always those intended by the authors of the primary research, it might be argued that some of the quality scores were therefore inappropriate for some evidence tables. The presentation of the data also was complex. Other areas for technical debate include the possible use of Receiver Operating Characteristic (ROC) analyses rather than relying solely on sensitivity and specificity. Some argue that this method captures more of the diagnostic information obtained, whilst others are less convinced.¹¹ Differences in the approach to histological validation employed represent a further challenge in this area. On the one hand in vitro studies are commended as they can

provide a true gold standard, on the other hand the differences between the diagnostic performance achieved in vitro and in vivo casts some doubt on the generalizability of the in vitro findings. Although very demanding in terms of logistics, the ideal study design would be to assess diagnosis in vivo first and then re-assess the same surfaces in vitro following extraction of the tooth (for some ethically acceptable reason). A further difficulty occurs when the gold standard classically employed is potentially less sensitive than some of the methods being tested against it.

Additional studies not included in the RTI/UNC review

The papers cited below provide a European perspective on many of the challenges to clinical caries diagnosis raised in the review. The diagnostic challenge now faced by clinicians should not be underestimated or regarded as a basic or undemanding skill. The presentation of the disease has changed at a time when the prevalence and incidence have slowed in some cases, but when the disease has become more polarized between risk groups and the range of preventive and operative treatment options has expanded.^{12,13} Although the clinical examination is the bedrock of daily dental practice, it is clear from many studies that clinical examination used alone in vivo will miss many lesions until they become so advanced that preventive intervention to avoid cavitation is compromised. The occlusal surface presents particular difficulties as gross cavitation seems to occur less frequently and the limitations of the clinical visual method have led to a fear of under-detecting hidden (or occult) lesions involving dentin.¹²

A contentious issue for many clinicians concerns the lack of evidence supporting the continued use of a sharp explorer as a diagnostic tool. Although its use as part of a visuo-tactile clinical method is widespread and has been widely taught for many years in many

countries, many European centers now teach that it is unethical to use an explorer in this way. This is because it has been shown many years ago in Sweden that iatrogenic damage can readily be produced, particularly on initial caries within occlusal fissures, and this action will favor continued lesion development.¹⁴ Similar findings were shown by Ekstrand and co-workers nearly twenty years later¹⁵ when it was also shown experimentally that the effect of probing with an explorer had a deleterious effect in terms of subsequent enamel demineralization.¹⁶ Apart from any risk of conveying cariogenic organisms from one fissure system to another, it is argued that a practice likely to cause harm to the patient cannot be justified if it fails to provide a significant balancing benefit. In this case, work showing the absence of any diagnostic benefit from the visual + tactile method over the visual only method means that the use of the sharp explorer to sense “stickiness” in occlusal fissures for primary caries diagnosis should be discontinued. A further complication with interpreting this literature is the difficulty of comparing studies that include established, open cavities in the assessment of occlusal caries diagnosis, with those confined to equivocal lesions.¹⁷

A significant extension of the well used clinical visual method of caries diagnosis on accessible free smooth surfaces can be made by temporarily separating adjacent teeth with elastomeric tooth separators commonly used in orthodontic practice.^{18,19} This allows a direct assessment of the presence or absence of surface cavitation to be made without exposing the patient to ionizing radiation to obtain a bitewing radiograph which cannot give a definite indication of the integrity of the approximal surface. Although the technique does require some practice and, in some cases, a further visit, it has been shown to be feasible in a general practice setting.²⁰ The clinical visual elective temporary tooth separation method can also be used in diagnostic research where the lack of clinical cavitation in approximal sites with

dentinal radiolucencies on bitewing radiographs has been striking.^{21,22} The probability of approximal cavitation has also been linked to caries activity.²³

The comparison of the relative merits of clinical visual and radiographic diagnoses represents an important area of changing practice as new evidence unfolds and evidence based guidelines are produced to inform clinical decisions.^{24,25} There is perceived to be an urgent need, given the deficiencies of clinical and other traditional caries diagnostic methods, for new methods which avoid the use of ionising radiation.²⁶ The comparative research of clinical and a number of other diagnostic methods brings with it methodological difficulties in combining the data in the most effective and useable way. Longbottom advocated two different strategies for this, contrasting using *adjunctive* additional methods - when the additional method(s) are used/counted only in those cases where the clinical diagnosis is sound, or using *supplemental* additional methods - when the highest-severest score from the clinical or additional method(s) are used/counted as the final diagnosis.²⁷ These approaches merit further consideration as new research work in this area unfolds. One neglected area of study is the diagnostic use of magnification in caries diagnosis.²⁸

Findings on clinical diagnosis from recent epidemiological literature

Further consideration of this topic can be found in the full version of this paper found on the web at <http://www.nidcr.nih.gov>.

Classically it has been claimed that recording caries at the D₁ threshold is associated with very poor examiner reproducibility. However, there is a growing body of evidence to demonstrate that if the training employed and the criteria used are appropriate, it is possible to achieve adequate levels of reproducibility. Kappa values of 0.82 at the D₁ threshold as

compared to 0.75 at the D₃ threshold have been reported by Deery who, in an earlier study, achieved a kappa value of 0.8 for the D₁ threshold examining Scottish adolescents.^{29,30} Similar values have been achieved by other examiners in vivo in adolescents³¹ and in examining four year olds; in vitro kappa values of around 0.7 have also been achieved.²⁸

Clinical diagnosis and clinical decision-making

Clinical diagnosis of dental caries plays a key part in clinical decision making and impacts on the provision of care that is appropriate in terms of both the evidence base for effective care and the needs of an individual patient.³²⁻³⁴ More work is needed to understand better the interplay between the diagnostic and treatment decisions made by general dentists, particularly as they relate to more preventive modes of care, such as fissure sealants,³⁵ and how dentists value features of new technology in different ways from their patients.³⁶ This should lead to the provision of clearer evidence based clinical guidelines for caries management³⁷ in different patient groups, including the socio-economically deprived with most disease.³⁸ Taken together and building on a synthesis of the information taken from the reviews presented at the Conference, this process should help clinicians to practice sound, effective and up-to-date caries prevention and management based on more accurate and reliable caries diagnosis.

A perspective on recommendations for clinical practice, education and research

Using the information presented in the RTI/UNC review, combined with the additional evidence cited in this contribution, a number of recommendations can be made to address the questions set out for the Consensus Development Conference (Table 1).

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Table 1: Recommendations in response to the relevant Conference Questions

Question 1. What are the best methods for detecting early-stage and late-stage dental caries?

1. Recognize that clinical caries diagnosis (with all its flaws) is the current foundation of lesion detection in Clinical practice, Clinical research, and Clinical epidemiology. The literature evaluating the method is mixed between these three applications and care is needed to separate out the objectives of use and the performance of the method in each field.
 2. Clinical visual methods of caries diagnosis are universally employed, are rapid, economical and acceptable for detecting early-stage disease (enamel lesions such as white and brown spot caries on accessible sites), non-cavitated dentinal lesions and late-stage cavitated caries. However, although the methods are inherently feasible, their inherent limitations must always be remembered.
 3. Although clinical diagnostic methods are highly specific, the low sensitivity achieved, particularly for non-cavitated occlusal surfaces in vivo, means that the use of diagnostic aids with superior performance is indicated and that new methods for caries diagnosis are required.
 4. Although the volume of high quality evidence on new diagnostic methods is lower than desirable, the very limited high-quality evidence available to support traditional clinical diagnostic methods means that clinicians cannot be complacent about the status quo.
 5. Given the potential for caries-inducing and caries-accelerating iatrogenic damage from the use of a sharp explorer in a visuo-tactile method, combined with the lack of any evidence of any additional diagnostic benefit, sharp explorers should no longer be used for the diagnosis of primary coronal caries in fissures.
 6. Continuing, effective undergraduate, faculty and postgraduate educational initiatives will be needed to share the evidence with teachers and clinicians in order to persuade those still using them to move away from sharp explorers.
 7. The continuum of the caries process and the long term benefits to the patient of preventive caries management should be more readily appreciated by practicing dentists and should thus be the subject of continuing, effective undergraduate, faculty and postgraduate educational initiatives
 8. The state of scientific knowledge regarding caries diagnosis (and related preventive management) in all three fields has moved forward, ahead of many traditional professional, regulatory and advisory frameworks, which should be objectively updated regularly.
 9. The concepts of diagnostic thresholds should be more widely understood and the use of the ambiguous term “caries free” should be avoided.
 10. It should be explicitly recognized that the current situation regarding the state of the art of caries diagnosis in clinical practice, clinical research and clinical dental epidemiology will need to alter with the continuing new developments in knowledge. Strategies for systematically sifting, grading and promoting the adoption of worthwhile new caries diagnostic approaches should be put in place internationally.
 11. Attempts should be made to harmonize epidemiological diagnostic methods in order to promote improved comparability and produce more reliable estimates of contemporary preventive care and restorative treatment needs.
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Question 5: How should clinical decisions regarding prevention and/or treatment be affected by detection methods and risk assessment?

1. There is a need for more reliable diagnostic methods to provide unambiguous indications of the extent, surface status and activity of lesions in order to plan appropriate care.
 2. There is a need for diagnostic methods that can reliably assess sealed surfaces.
 3. There is a need for better tools for the diagnosis and treatment planning of secondary caries, given the proportion of repeat dentistry currently carried out.
 4. Before a decision to restore is made, clear evidence of significant cavitation or progressive dentinal involvement should be required.
 5. Results of clinical diagnosis should be able to be fed into preventively-biased clinical decision frameworks compatible with a **NCA, PCA, PCA + OCA** style of classification in order to avoid the premature restoration of small non-cavitated lesions.
 6. There is a need for valid, reliable, automated clinical decision support systems
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Question 6: What are the promising new research directions for the prevention, diagnosis and treatment of dental caries?

1. There is a need for more effective primary preventive products.
2. There is a need for specific secondary preventive products that can deliver reliable lesion reversal *prior* to the cavitation stage ever being reached.
3. There is an urgent need for more high quality studies that are well conducted and well reported using an internationally agreed common minimum data set for reporting.
4. There is a need for more studies evaluating the same lesions both in vivo and in vitro.
5. There is a need for more studies evaluating caries diagnosis in primary teeth
6. There is a need for more studies evaluating diagnostic performance at the caries into enamel and dentin D₁ threshold.
7. There is a need for more studies on combinations of diagnostic methods, with *adjunctive* and *supplemental* analyses.
8. There is a need for more sensitive, specific, reliable, objective diagnostic methods to indicate sites vulnerable to lesion progression *prior* to too much damage being done – i.e., tools to specifically cater for early stage caries
9. There is a need for diagnostic tools to cater for lesions around the size/extent at which restorative intervention is indicated, in order to monitor the outcome of aggressive preventive care.
10. There is a need for diagnostic tools tailored for rapid, reliable and accurate use in epidemiological settings.
11. There is a need for diagnostic tools to specifically detect hidden dentine caries
12. There is a need for better dental materials with physical properties that more closely match tooth tissue and the ability to react intelligently as a caries preventive agent when presented with a caries challenge.
13. There is also a need to develop the evidence base on how to disseminate effectively the findings of systematic reviews in dentistry and, having achieved that, to establish how any changes in clinical practice, which might be indicated, can best be brought about.

Figure 1a – conceptualising the caries process

The “iceberg of dental caries” 2001- varying diagnostic thresholds & applications

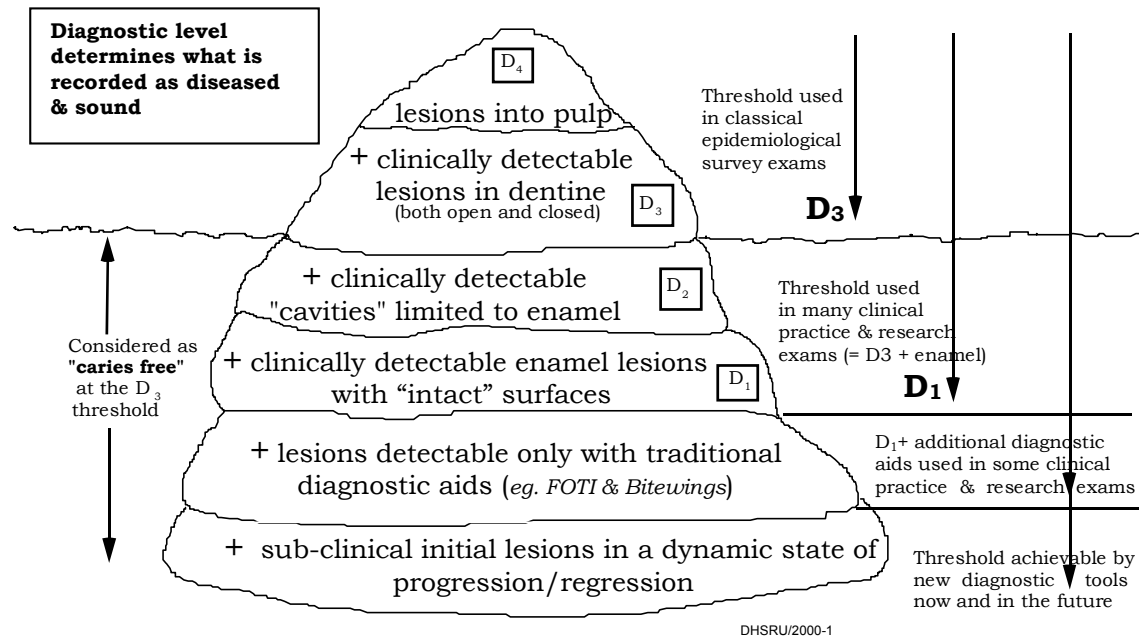


Figure 1b– linking diagnosis to clinical management

NCA/PCA/OCA 2001 - informing clinical decisions about prevention & operative care

